March 24, 1931. **S. BRAND ET AL** **1,797,317**

BINAURAL PHASE DISCRIMINATION RADIO SYSTEM

Filed Dec. 20, 1928 2 Sheets-Sheet 1

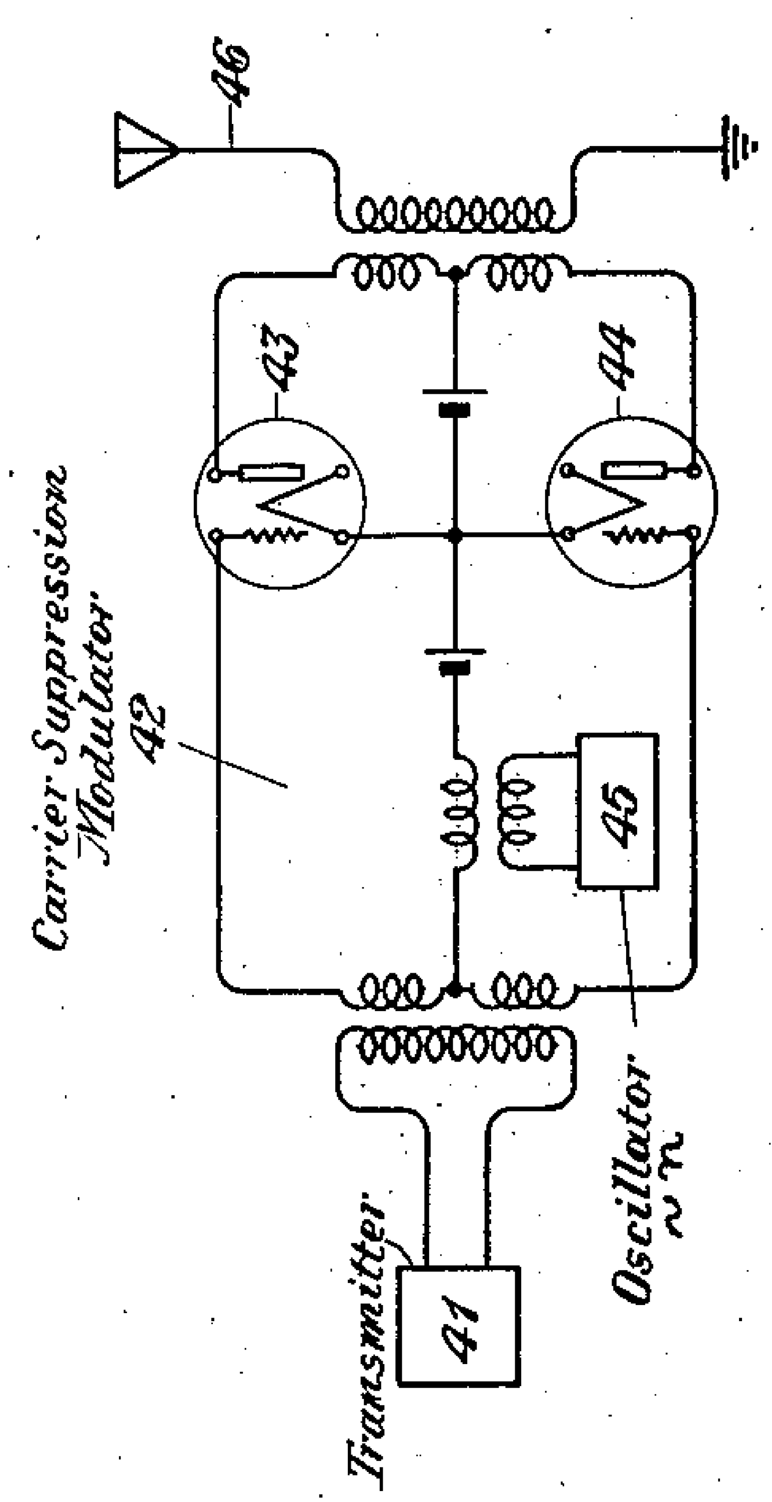

Fig. 1

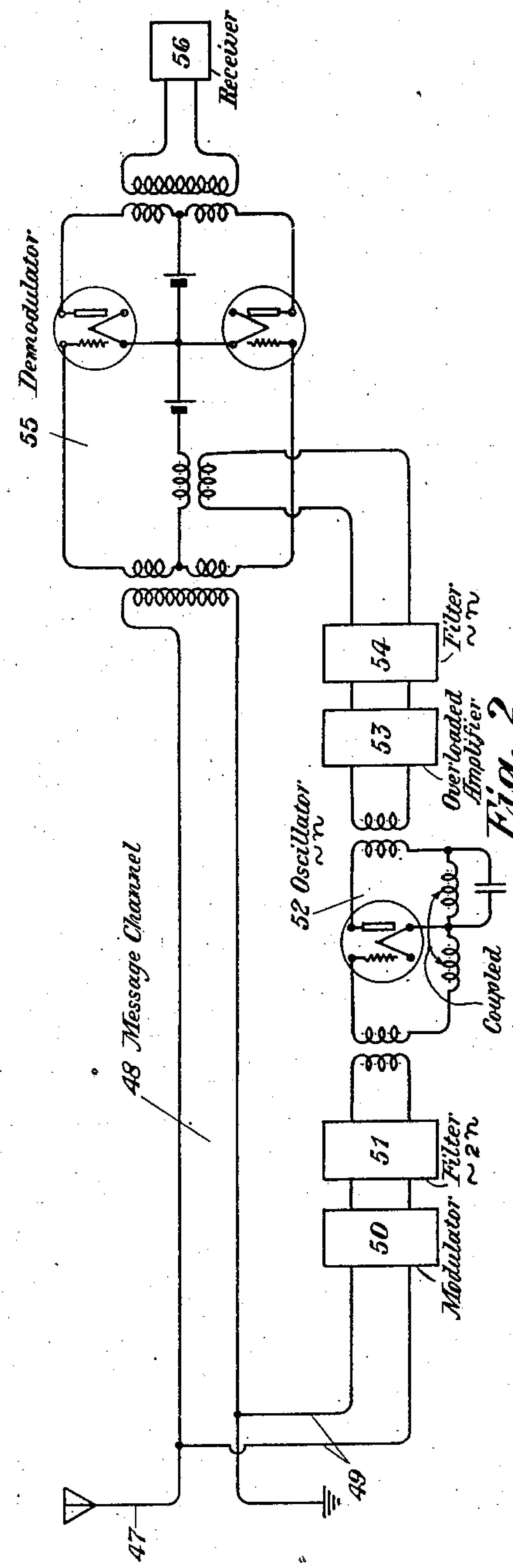

Fig. 2

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BINAURAL PHASE DISCRIMINATION RADIO SYSTEM

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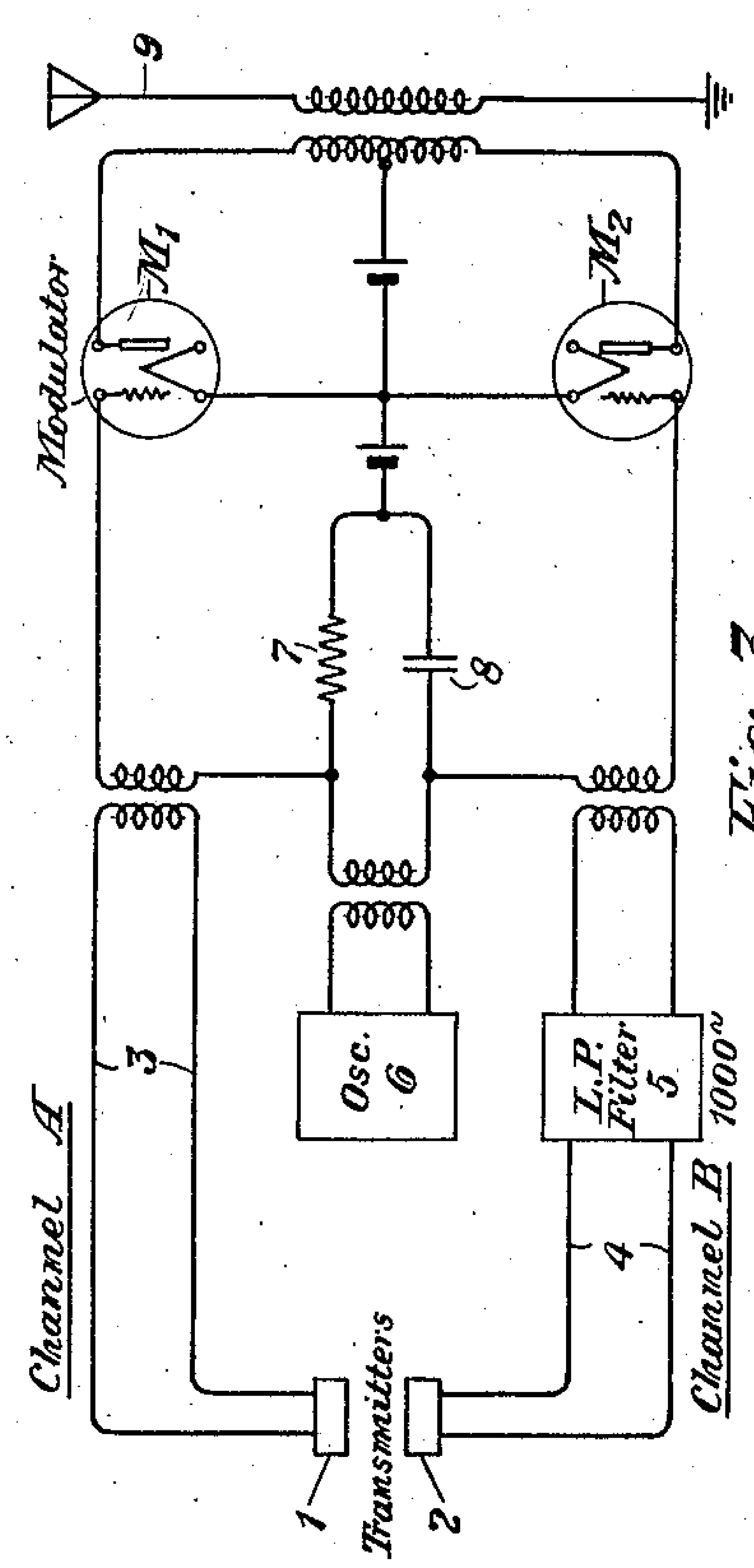

Fig. 3

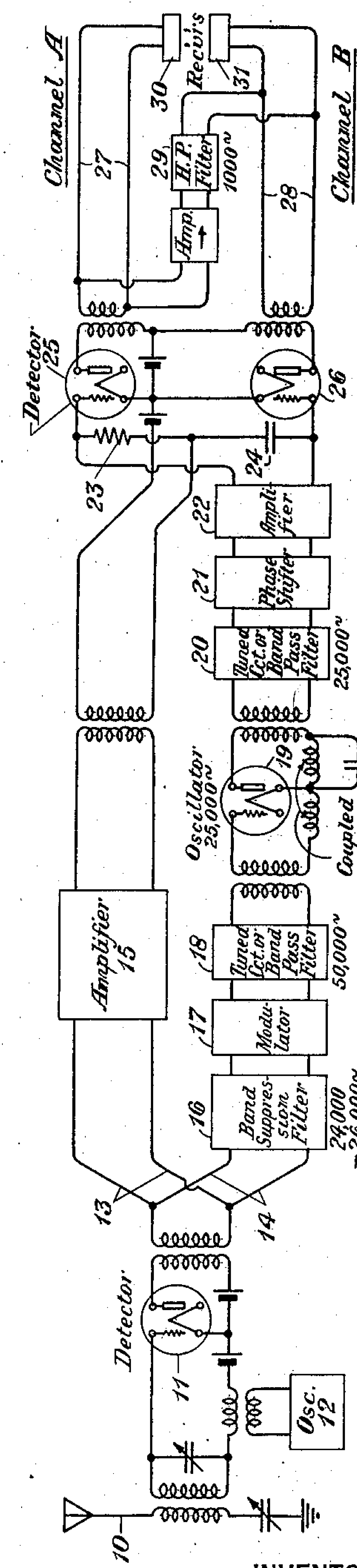

Fig. 4

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UNITED STATES PATENT OFFICE

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BINAURAL PHASE-DISCRIMINATION RADIO SYSTEM

Application filed December 20, 1928. Serial No. 327,382.

This invention relates to high frequency signaling systems and more particularly to a method of homodyne reception which may be utilized in such systems. The invention furthermore relates to certain specific systems in which the reception method may be employed.

The homodyne reception method of the invention is particularly adapted for use in a system of the carrier suppression type. In this type of system current from the transmitter modulates the output of an oscillator in a carrier suppression modulator of the usual balanced type. Thus, there are impressed on the antenna the two signal sidebands, the carrier being omitted. This type of system is well known in the art. In this type of system it is essential that the carrier currents used for detection in the receiving set, whether transmitted or generated locally, should have definite, constant phase relations with the carrier currents used at the transmitting station. It is one of the primary objects of the homodyne method of this invention to insure that the carrier current used for detection in the receiving set have definite and constant phase relations with the carrier currents used at the transmitting station.

In accordance with the arrangements of the invention there will be provided at the receiving station, a by-pass from the message channel. This will lead to a modulator in which the two transmitted signal side bands are modulated together. Among the products of modulation will be the harmonics of the carrier frequency. A desirable one of these such as the second harmonic, is selected from the others by means of a tuned circuit or narrow band-pass filter and used to control the frequency and phase of a local oscillator of the carrier frequency.

Various methods of controlling the frequency and phase of an oscillator by one of its harmonics are well known in the art. The method of control shown in this invention, is simple coupling of the harmonic supply circuit with the grid circuit of the oscillator. The output of the oscillator will contain the carrier frequency and its harmonics. The output from the oscillator is passed through an overloaded amplifier, whose power output will hence be substantially independent of its power input for normal inputs. The carrier frequency is selected by filter apparatus from the output of the amplifier and applied to a demodulator in the usual way. By utilizing the reception method of this invention, it will be seen that the carrier current used for detection in the receiving set will have definite and constant phase relationship with the carrier currents used at the transmitting station.

One of the particular uses to which the homodyne reception method of the invention might be put is in a transmission system of the binaural type by means of which it is possible to give a listener an idea of the position of the source of sound producing the transmitted signal.

It is well known from the results of tests that the naturalness of sounds transmitted over electrical systems is greatly increased by the use of binaural transmission, i. e., transmitting independently to each ear of the listener the sounds "picked up" by two transmitters separated from each other by a distance approximately equal to that between the listener's ears. The use of phase discrimination principles to obtain these two independent message channels for a radio system so that the sounds may be transmitted binaurally over a single radio frequency channel (this necessitating only one transmitting and one receiving antenna system) has been disclosed in the art in a Patent #1,608,566, to R. K. Potter, November 30, 1926.

It is pointed out that in systems of the type illustrated in the above patent it is essential that the carrier currents used for detection in the receiving set, whether transmitted or generated locally, should have definite, constant phase relations with the carrier currents used at the transmitting station. One of the methods in the above mentioned types of systems has been to employ for this purpose the usual component of the carrier frequency in the transmitted output. This component will be the resultant of two similar components

90° apart in phase, one for each of the two independent message channels. However, it has been found that there are important limitations in the use of said carrier component or resultant in this connection. This is due to the fact that, since the two channels are independent the components of the carrier frequency in these will vary in magnitude independently. This will vary the phase of the resultant with respect to either of the carrier components, thus violating the requirement that such phase angle be constant. This effect is more pronounced as the modulation is greater—the limitation therefore consists in the necessity of keeping the modulation small.

In the particular embodiment of the arrangements of the invention as applied to a binaural transmission system, utilization is made of the well known fact that frequencies above 800 cycles do not give much binaural effect. Consequently, these frequencies (or say about 1,000 cycles, to give some margin) need be transmitted over only one channel, say, for example, the channel A. At the receiving end of the system a parallel circuit in derivation to the main circuit is provided, passing only frequencies 1,000 cycles or more away from the carrier frequency. In other words, there will exist in this circuit two side bands resulting from the modulation from channel A alone. Accordingly this would eliminate any variations in phase of a resultant caused by independent modulation of its components from the two channels, respectively, as in former arrangements. These two bands are then modulated together. Among the products of modulation will be the second harmonic of the carrier frequency. This will have a constant phase relation with the original carrier current, independent of the modulation. This is selected from the others by a tuned circuit or narrow band pass filter and used to control the frequency and phase of an oscillator of the carrier frequency. Various methods of controlling the frequency and phase of an oscillator by one of its harmonics are well known in the art. The method of control shown in this invention is simple coupling of the harmonic supply circuit with the grid circuit of the oscillator. The output of the oscillator will contain the carrier frequency and its harmonics. The fundamental is selected by means of a tuned circuit or narrow band pass filter. This current will have an unvarying phase relation with the modulated current in channel A and, therefore, with that in the other channel B. It then goes through a phase shifter to the phase discrimination apparatus. The last operation will be to supply the missing frequencies above 1,000 cycles in channel B through a by-pass from channel A.

The invention may be more fully understood from the following description, together with the accompanying drawing in the Figures 1, 2, 3 and 4 of which the invention is illustrated. Figs. 1 and 2 are circuit diagrams of transmitting and receiving stations, respectively, embodying the homodyne method of reception of the invention. Figs. 3 and 4 are circuit diagrams of transmitting and receiving stations, respectively, illustrating how the principles of the invention may be applied to a binaural transmission system.

In Fig. 1 is shown a circuit diagram of a transmitter station for a high frequency signaling system. A transmitter 41 is shown connected to a balanced type of carrier suppression modulator 42 of which the two vacuum tubes 43 and 44 are shown. An oscillator 45 supplies the carrier frequency n. The antenna 46 is shown. The balanced type of carrier suppression modulator 42 is well known in the art. The current from the transmitter 41 modulates the output of oscillator 45 and there will be impressed on the antenna 46 the two signal side bands, the carrier being omitted.

In Fig. 2 is shown a receiving system adapted to receive signals from the transmitting station of Fig. 1 and comprising the arrangements of the invention. The receiving antenna 47 is shown connected to a message channel circuit 48. Bridged across circuit 48 is a by-pass circuit 49 leading to a modulator 50. The two side bands transmitted from the arrangements of Fig. 1 are modulated together in the modulator 50. Among the products of modulation will be harmonics of the carrier frequency n. A desirable one of these such as the second harmonic $2n$ of the carrier frequency n will be selected from the others by means of a tuned circuit or narrow band-pass filter 51. It will then be applied to an oscillator 52 of the frequency n to control its phase and frequency. The second harmonic frequency supply circuit is simply coupled with the grid circuit of the oscillator. As is well known, this will keep the phase and frequency of the oscillator 52 the same as that of the carrier frequency n at the transmitting station. The output of the oscillator 52 is then passed through an overloaded amplifier 53, whose power output will hence be substantially independent of its power input, for normal inputs. The carrier frequency n is selected by the filter 54 from the output of this amplifier and applied to the demodulator 55 in the usual way. The message currents will then be received by the receiver 56.

In Fig. 3 are shown two transmitters 1 and 2 connected to circuits 3 and 4, whereby the separate channels A and B may be transmitted to the tubes M_1 and M_2 of a modulator of the well known duplex type. Associated with the modulator is an oscillator 6. Current from this oscillator, of carrier frequency, is passed through a resistance 7 and a condenser 8 in series. The potential differences across these will be 90 degrees out of phase with each other. On one and another of these, respectively, are superimposed the modulating currents from channels A and B. After modulation the currents from the two channels will be transmitted to the antenna 9 for transmission to a distant station. It is pointed out that in circuit 4 there is inserted a low pass filter 5 which will cut off frequencies which do not have any material binaural effect, such as frequencies about 1,000 cycles. Accordingly channel B will contain only frequencies below 1,000 cycles, while channel A will include all frequencies in the signal range.

In Fig. 4 is shown a station comprising the receiving antenna 10 connected to a main receiving circuit. In the main receiving circuit there might be located a detector 11, a local oscillator 12 and tuning devices. This would permit a receiving set of the arrangements of the invention to be used in a broadcasting system where several broadcasting stations might be working on different wave lengths. A receiving set utilizing double detection as shown might change reception from one broadcasting station to another without requiring a complicated change in the arrangements of filters in the set to be described hereinafter and sets might be made of uniform construction. In the above arrangements the incoming modulated radio frequency would first be beaten by the local oscillator 12 to produce a current of, say, 25,000 cycles, similarly modulated. The filtering arrangements of the sets could be designed to utilize such a frequency as a standard. The phase characteristics, which permit phase discrimination, are preserved throughout this modification. However, the above double detection scheme is not essential and is only illustrated as a matter of choice. The incoming modulated currents from the sending station of Fig. 3 might be received in a simple receiving circuit connected to the antenna 10.

The receiving circuit connected to antenna 10 is divided into two parallel circuits 13 and 14. Circuit 13, which may include the amplifier 15, may be termed the message circuit and will transmit channels A and B to the detector and phase discrimination apparatus. This arrangement includes the detector tubes 25 and 26, the resistance 23 and condenser 24 arranged as shown, and is well known in the art. The circuit 14 is the circuit utilized for deriving the carrier frequency to be used for detection and phase discrimination purposes. It has been pointed out that this current should have definite and constant phase relations with the carrier generated at the transmitting station. In the circuit 14 will be a band suppression filter 16. This filter will be designed to suppress a band of frequencies 1,000 cycles on each side of the carrier which has for purposes of convenience been termed 25,000 cycles. Accordingly, this filter will eliminate from the carrier any effect of the channel B which has been pointed out will only transmit frequencies up to 1,000 cycles due to the filter 5 at the sending station. Accordingly, the result will be the existence of two side bands from the channel A only, or the portion thereof above 1,000 cycles. This will eliminate the defect in former systems of a variation in phase of the resultant carrier due to modulation of the carrier by both channels. These two side bands 1,000 cycles away from the carrier will be modulated together in the modulator 17. Among the products of modulation will be the second harmonic of the carrier frequency. This second harmonic will be selected from the others by the filter 18 and used to control the frequency and phase of an oscillator 19 of the carrier frequency. Various methods of controlling the frequency and phase of an oscillator by one of its harmonics are well known in the art. The method of control illustrated is simple coupling of the harmonic supply circuit with the grid circuit of the oscillator. The output of the oscillator will contain the carrier frequency and its harmonics. The fundamental is selected by means of the filter 20. This current will have an unvarying phase relation with the modulated current in channel A and, therefore, also with that in channel B. It then goes through the phase shifter 21 and the amplifier 22 to the phase discrimination apparatus heretofore referred to which is well known in the art. The outputs of the two detector tubes 25 and 26 are connected respectively by the circuits 27 and 28 to the receivers 30 and 31 for binaural reception. The missing frequencies above 1,000 cycles in channel B are supplied thereto through a by-pass circuit from channel A including the filter 29 which passes frequencies above 1,000 cycles. It will be noted that the required phase relations hold only when the circuit is in actual use, as it requires a modulating current in channel A of a frequency over 1,000 cycles. When the circuit is idle there will be no control over the phase of the oscillator 19, but, of course, none will be needed. As soon as the circuit is in use again, signals will be sent over channel A and current will flow to control the phase of the oscillator 19. There will be a short interval of time required before this control is accurate, but this will be only a few cycles of the carrier frequency and will be imperceptible to the ear. Since the oscillator 19 is controlled by its second harmonic there may occur a phase change of 180° after the silent period. This corresponds to a reversal in poling of both the receivers and will therefore have no effect on the ear.

This application is a continuation in part of our application, Serial No. 230,888, filed November 3, 1927.

While the invention has been described in certain specific arrangements which are deemed desirable, it is understood that it is capable of embodiment in many and other widely varied forms without departing from the spirit of the invention as defined by the appended claims.

What is claimed is:

1. In a system for the binaural transmission of signals the method which consists in the modulation of a carrier by signal variations resulting from sound waves, producing another set of signal variations resulting from sound waves from the same source but with frequencies in a band not materially contributing to the binaural effect eliminated therefrom, modulating by said second set of signal variations carrier oscillations of the same frequency as employed in the first mentioned modulation operation but differing in phase by 90° therefrom, and transmitting both sets of side bands.

2. In a system for the binaural transmission of signals the method which consists in the modulation of a carrier by signal variations resulting from sound waves, producing another set of signal variations resulting from sound waves from the same source but with frequencies in a band not materially contributing to the binaural effect eliminated therefrom, modulating by said second set of signal variations carrier oscillations of the same frequency as employed in the first mentioned modulation operation but differing in phase by 90° therefrom, transmitting both sets of side bands, deriving at the receiving station from the transmitted side bands, two side bands including only those frequency components not materially contributing to the binaural effect, combining the derived side bands to produce a resultant frequency related to the corresponding carrier, and controlling the phase and frequency of the carrier used for detection by said resultant frequency.

3. In a system for the binaural transmission of signals the method which consists in the modulation of a carrier by signal variations resulting from sound waves, producing another set of signal variations resulting from sound waves from the same source but with frequencies above 1,000 cycles eliminated therefrom, modulating by said second set of signal variations carrier oscillations of the same frequency as employed in the first mentioned modulation operation but differing in phase by 90° therefrom, transmitting both sets of side bands, producing at the receiving station from said resultant carrier two side bands having frequency limits 1,000 cycles away from said carrier, combining the derived side bands to produce a resultant frequency related to the corresponding carrier, and controlling the phase and frequency of the carrier used for detection by said resultant frequency.

4. In a high frequency signaling system the method of receiving messages which comprises modulating the transmitted side bands together without the corresponding carrier, selecting from the product of such modulation one of the harmonics of the carrier frequency to which the side bands correspond, and utilizing said selected harmonic frequency to control the phase and frequency of the local carrier frequency utilized for detection.

5. In a high frequency signaling system the method of receiving messages which comprises modulating the transmitted side bands together without the corresponding carrier, selecting from the product of such modulation a desirable harmonic of the carrier frequency to which the side bands correspond, utilizing said selected harmonic frequency to control the phase and frequency of a locally generated carrier frequency so that it will have a predetermined frequency and phase relationship with respect to the carrier used at the transmitting station, and utilizing said locally generated carrier frequency as so controlled for detecting said transmitted side bands.

6. A high frequency signaling system comprising a transmitting station, means whereby the carrier is suppressed from the side bands, a receiving demodulator, a circuit whereby said side bands may be applied to the input of said demodulator, a local oscillator connected to said demodulator, a circuit in parallel with said demodulator input circuit, a modulator in said circuit to which said side bands are applied, selective means associated with said modulator output for selecting a harmonic of the carrier frequency corresponding to the applied side bands, and means to couple the output of said selective means to said oscillator.

7. A high frequency signaling system comprising a transmitting station, means whereby the carrier is suppressed from the side bands, a receiving demodulator, a receiving circuit for said side bands connected to said demodulator, a second circuit connected to said receiving circuit, a modulator in said circuit to which said side bands are applied, selective means in said circuit connected to said modulator output for selecting a harmonic of the carrier frequency corresponding to the applied side bands, an oscillator having its input circuit coupled to said selective means, a second selective means connected to the output of said oscillator for selecting a current of the frequency of said

carrier, and means to impress said selected current on said demodulator for detecting said side bands.

In testimony whereof, we have signed our names to this specification this 17th day of December, 1928.

SMART BRAND.
PIERRE MERTZ.